APPENDIX B

TECHNICAL MEMORANDA FROM COLORADO AND WYOMING CONCERNING QUANTIFICATION OF CURRENT AND FUTURE DEPLETIONS FROM THE YAMPA RIVER BASIN

M E M O R A N D U M

TO: Yampa River Hydrology Subcommittee

FROM: Ray Alvarado

DATE: November 6, 2000

SUBJECT: Yampa River Modeling Assumptions under “Current Level” of Depletions

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As requested during the November 3, 2000 Hydrology Subcommittee conference call, I have written down the new modeling assumptions to be used for power, M & I and agriculture uses under "current level of depletions.

Demands

- For the period 1975-1998, irrigation demands will be taken directly from the Calculated data set. For the period prior to 1975, demands will be estimated using the average of the 1975-1998 Calculated demands for the same month and hydrologic condition, but *without* constraint of net cumulative decree. Does not include any fallow lands that maybe irrigated in the future.
- Municipal demands will be set to 1998 demand levels.
- Industrial demands will set to monthly averages over 1985-1998. Public Service as well as Tri-State will submit these monthly demands to the CWCB.
- Transbasin diversion demands will be set to average monthly diversions over the period 1975-1998.

M E M O R A N D U M

TO: Yampa River PBO Water Subcommittee

FROM: Ray Alvarado

DATE: November 21, 2000

SUBJECT: Yampa River Modeling Results

Pursuant to the Water Subcommittee's November 3 conference call, I have summarized the latest Yampa modeling results using the Subcommittee's revised assumptions for power, M & I and agricultural depletions under "current" levels of demand, as well as projected depletions under 2045 demand conditions. The following tables do not include Water District 56.

Depletions under "ideal" conditions assumed that water supply is not a limiting factor.

Table 1
Average depletions under "ideal" conditions, values in acre-feet

Use	Current Level	Change	2045 Level	Comments
Agriculture	92,258	0	92,258	No Change
M & I	5,202	10,105	15,307	BBC Projected Increase
Power	16,947	15,403	32,350	BBC Projected Increase
Exports	2,917	0	2,917	No Change
Evaporation	12,543	0	12,543	No Change
Totals	129,867	25,508	155,375	

Table 2 summarizes the modeling results when physical and legal availability constraints are placed on the "ideal" demands. There are changes from values listed in my June 26, 2000 memorandum. These are mainly due to "new" averages being used. For M & I, the decrease of 210 ac-ft is due to an incorrect starting value. This was corrected for this effort.

Table 2
Average modeled depletions , values in acre-feet

Use	Current Level	Change	2045 Level	Comments
Agriculture	87,765	-10	87,755	Affected by senior M&I and Power
M & I	5,201	9,899	15,100	BBC Projected Increase
Power	16,947	15,403	32,350	BBC Projected Increase
Exports	2,815	0	2,814	No Change
Evaporation	12,543	0	12,543	No Change
Totals	125,271	25,292	150,562	

The shortages shown in Table 3 are partly due to the increase power demands as well as physical supply limits. Some of the agriculture depletion shortages occur due to the operation of Wyoming's demands in Water District 54 as well as the method of calculating irrigation efficiencies.

Table 3
Average modeled depletion shortages from "ideal", values in acre-feet

Use	Current Level	2045 Level
Agriculture	4,493	4,503
M & I	1	207
Power	0	0
Exports	102	103
Evaporation	0	0
Totals	4,596	4,813

TECHNICAL MEMORANDUM

SUBJECT: **Green River Basin Plan**
Wyoming Depletions in the Little Snake River Basin

PREPARED BY: States West Water Resources Corporation
Revision made August 23, 2000 by Wyoming State Engineer's Office

Introduction

The Little Snake River is not directly tributary to the Green River in Wyoming. It is tributary to the Yampa River which ultimately flows into the Green in Dinosaur National Monument in northwestern Colorado. A programmatic biological opinion will be prepared to address the potential effects of the "Management Plan for Recovery of the Endangered Fishes of the Yampa River Basin and Continuation of Existing Human Water Uses and Future Water Development." The purpose of the Management Plan is to allow for the use and future development of Yampa River Valley water resources and to protect and promote the recovery of the four endangered fish species which reside in the Upper Colorado River Basin. The development of the Management Plan is occurring as an activity of the ongoing Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin, which has been ongoing since 1988. The State of Wyoming is a participant in the Recovery Program and is participating in the development of the Management Plan. This memorandum documents current estimates of depletions due to activities in Wyoming, and presents estimates of depletions out to year 2045.

The average annual water yield from the Little Snake River Basin in total is 428,000 acre-feet (Hawkins and O'Brien, 1997). Sources of depletions in Wyoming include irrigated agriculture, environmental use, municipal use and transbasin diversions for the City of Cheyenne. As of 1994, total Wyoming depletions in the basin were estimated at 39,900 acre-feet annually (Burns & McDonnell, 1999, Appendix D).

No current depletions are explicitly associated with either industrial or domestic uses. Industrial uses are small and generally included within municipal demand estimates. Domestic uses are also small. To the extent they are comprised of individual small wells serving residential populations, domestic uses will not significantly affect surface water flows.

Therefore, determination of current and future demands consists of updating municipal, agricultural and City of Cheyenne depletions, and projecting them out to year 2045. Additional depletions are estimated for future environmental and industrial uses.

Municipal Depletions

According to Purcell (2000), municipal demands in the Little Snake River Basin are created by uses in the towns of Baggs and Dixon. Between the two, a total of 76 acre-feet of water is currently depleted. Burns and McDonnell (ibid.) provide a higher current municipal depletion of 106.8 acre-feet. Current population estimates are 375, 300 for Baggs and 75 for Dixon, for a current use rate of 0.20 acre-feet/person-year using Purcell's numbers. To project these depletions to year 2045, population projections outlined by Watts (2000) are used. While Watts proposes three growth scenarios, only the moderate growth scenario is used herein. This scenario is based on U.S. Census Bureau projections.

According to Watts, Baggs and Dixon, together, would experience total growth of 10.8 percent from 2000 to 2030. Projected to 2045, or another 15 years beyond the 2030 horizon looked at by Watts, gives a growth total of 16.2 percent. This projection is performed by linear extrapolation, which is satisfactory in this case because the moderate growth curve is linear in later years.

Therefore, projecting municipal demands consists of taking existing use and increasing it by the expected percentage population increase. A current depletion of 76 acre-feet annually, increased by 16.2 percent, gives a 2045 municipal depletion of 88 acre-feet per year.

City of Cheyenne Depletions

Part of the City of Cheyenne's water supply system is comprised of the Stage I and Stage II Projects. These projects consist of collection and transmission systems in the Little Snake River Drainage. Water is collected from several tributaries of the Little Snake River and delivered to a tunnel that transports the water under the continental divide to Hog Park Reservoir in the North Platte River Basin. Storage in Hog Park Reservoir is released to replace water diverted to Cheyenne through the Rob Roy supply components of the Stage I and II Projects, which transport water from the North Platte River Basin to the South Platte River Basin. The current amount of water diverted from the Little Snake Basin, based on the 1995-1997 usage period, is 14,400 acre-feet per year.

Maximum annual capacity of the Stage I/II system is dictated by the larger of the potential yield of this system (21,000 acre-feet, Black and Veatch, 1994) versus the one-fill limitation on Hog Park Reservoir (22,656 acre-feet). In this case, maximum potential depletion allowed to the Little Snake River Basin is therefore 22,656 acre-feet. The City of Cheyenne has no current plan to enlarge the Stage I/II system, however, its capacity will be reached in the 2040-2050 time frame under current growth estimates.

Agricultural Depletions

Agricultural depletions arise from the consumptive use of water by irrigated crops and pasture. Determination of this depletion requires estimates of the current irrigated acreage in the basin and of actual crop consumptive requirements.

O'Grady, et al, (2000) calculated the amount of irrigated lands in the Little Snake Basin using 1983-1984 aerial photography corrected by 1997-1999 infrared satellite imagery. This work resulted in an estimate of current irrigation of Wyoming lands totaling 15,929 acres. Crop distribution in the basin was previously estimated to be 75 percent grass hay, 11 percent alfalfa and 14 percent irrigated pasture (Western Water Consultants, 1992).

Maximum consumptive use of these crops is only achieved with a full water supply. Consumptive irrigation requirement (CIR) at Dixon, or that amount needed in excess of rainfall to produce a crop, was determined by Trelease et al. (1970), as modified by Pochop, et al. (1992) to be 22.78 inches (1.9 feet) for alfalfa and 20.96 inches (1.75 feet) for pasture grass (or grass hay). Modifications to these numbers to include mountain meadow hay were developed for the Green River Basin Water Plan. For this type of hay, it has been determined that the irrigated lands above Baggs would experience 19.59 inches (1.63 feet) of annual CIR. For purposes of depletion estimation, the following distribution was used: lands above Baggs were represented by 89 percent mountain meadow hay and 11 percent alfalfa, with lands below Baggs represented by 89 percent pasture grass/grass hay and 11 percent alfalfa. From irrigated lands mapping, there exist 11,571 acres above Baggs and 4,358 acres below Baggs.

Under the cropping and irrigated lands percentages given above, the total crop-weighted CIR would be as follows:

Crop	Above Baggs	Below Baggs	Total
Grass Acres	10,298	3,879	14,194
Meadow/Grass CIR, ft.	1.63	1.75	
Grass Total CIR, AF	16,786	6,788	23,574
Alfalfa Acres	1,273	479	1,755
Alfalfa CIR, ft.	1.9	1.9	
Total Alfalfa CIR, AF	2,419	910	3,329
Total CIR, AF	19,205	7,698	26,903

These CIR calculations equate on a crop-weighted basis to 1.66 feet of CIR above Baggs and 1.77 feet below Baggs. Estimates of actual agricultural depletions (and review of irrigation diversion records) have shown less depletion than full CIR would dictate, which is to be expected. Estimates of agricultural depletion, based on studies prepared for High Savery Reservoir (Burns and McDonnell, ibid.), indicate the basin to currently receive about a 75 percent supply without storage. Current agricultural depletions are therefore estimated to be 20,050 acre-feet per year. It is recognized that in practice full CIR is usually not achievable unless fields are flat and irrigation timing is precise. Nonetheless, full CIR values provide a reasonable calculation of the needs and demands of the aggregate irrigation in the basin.

High Savery Dam

Depletions associated with the High Savery Dam project are expected to average 7,724 acre-feet per year as given in the Record of Decision, Final Environmental Impact Statement, Little Snake Supplemental Irrigation Water Supply project (Department of the Army Corps of Engineers, June 5, 2000). Of this amount, approximately 869 acre-feet per year is attributable to evaporation from the reservoir itself, leaving 6,855 acre-feet as the depletion associated with supplemental irrigation practices. This project assumes no additional irrigated acres will be brought under production; it provides supplemental late-season water to existing lands. Adding the 20,050 acre-feet of existing depletion to 6,855 acre-feet due to High Savery provides a total agricultural depletion of 26,905 acre-feet, or essentially a 100 percent water supply based on full CIR. Because High Savery has already had a biological opinion issued, it is included in the environmental baseline under current depletions even though it has yet to be constructed.

Other Projects

In 1995, several dikes were permitted on Muddy Creek by the Little Snake River Conservation District with assistance from several state and federal agencies, including the Wyoming Water Development Commission, the Bureau of Reclamation, and the Bureau of Land Management. These dikes, and the impoundments behind them, are permitted for stock and wetland purposes, and have since been constructed.

According to the reservoir permit maps, the three constructed impoundments have a total surface area of 113.5 acres, resulting in an evaporative depletion of 284 acre-feet per year at a net evaporation rate of 30 inches.

Future Depletions

The projects listed below were developed in large part with input from the Little Snake River Conservation District, and reflect their plans and desired ability to further develop the water resources of the basin.

Environmental Uses

Additional Wetlands Construction

The Little Snake River Conservation District has demonstrated the desire and ability to construct wetland habitat for wildlife, stock and riparian benefits. As quantified earlier, the District in the last 5 years has constructed wetlands with estimated depletions amounting to almost 300 acre-feet per year. Future efforts by the District are anticipated to increase the amount of wetlands by a factor of three, thus creating a future depletion on the order of 1,000 acre-feet.

Little Snake River Basin Small Reservoirs Project

A feasibility report evaluating several small reservoirs in the basin was completed by Lidstone and Anderson in 1998. This report, sponsored by the Little Snake River Conservation District, looked at the feasibility of constructing up to 34 small impoundments for purposes of stock watering, rangeland improvement, and wildlife enhancement. The study resulted in a list of 12 reservoir sites to be considered

for Level III design and construction funding. Currently, one reservoir is slated for construction with a second dependent on the availability of funding. For this estimate, the two slated for construction funding are considered as existing depletions, and the remaining ten considered as adding depletions for the 2045 scenario.

The two impoundments under existing funding are Ketchum Buttes 25 and Smiley Draw 27. State Engineer records indicate reservoir surface areas of 10.6 and 8.9 acres, respectively. Assuming a net evaporation of 30 inches (same as High Savery Dam, considered as representative), the total depletions for these impoundments average 49 acre-feet per year (27 and 22 acre-feet, respectively).

The 10 impoundments for possible future construction are as follows:

Reservoir	Surface Area, ac.	Depletion, acre-feet
Blue Gap 16	50.1	125
Blue Gap 27	14.6	37
Browns Hill 21	2.9	7
Garden Gulch 3	2.8	7
Garden Gulch 32	19.9	50
Ketcham Buttes 34	5.5	14
Peach Orchard Flat 34	88.6	222
Pine Grove Ranch 1	7.7	19
Pole Gulch 27	0.7	2
Riner 28	52.2	131
Total		**614**

Agricultural Uses

Miscellaneous Stock Reservoirs

The Little Snake River Conservation District has indicated that due to siltation and other causes of loss, stock reservoirs are being replaced and will continue to be replaced over the next 45 years. Hundreds of stock reservoirs currently exist in the basin, and at the rate of five per year over 200 new ponds will be constructed by 2045. These new ponds will vary in size, and it is estimated that up to 2,000 acre-feet of depletion will be attributable to their construction and storage.

Dolan Mesa Canal

Currently there is a water right and one enlargement for an irrigation supply project from Savery Creek, the Dolan Mesa Canal. Together, these rights are permitted to serve 1,600 acres. The lands are currently not irrigated, but the possibility exists that current or subsequent owners may try to bring the lands under irrigation. If all 1,600 acres were irrigated, depletion estimates (using 1.66 feet of CIR) would total 2,656 acre-feet.

Willow Creek Storage

Users in the State of Colorado are seeking to implement a storage project on Willow Creek, which flows into the Little Snake River south of Dixon, WY.. The Little Snake River Conservation District has expressed interest in becoming a joint applicant in the project to increase its size and serve lands in Wyoming. Under a Willow Creek reservoir, approximately 1000 acres would be served. The depletion associated with this use would amount to 1,660 acre-feet.

Cottonwood Creek

The Little Snake River Conservation District has indicated that a project is being considered that would have its source of supply water from Cottonwood Creek, tributary to the Little Snake River north of Dixon, WY. The project, anticipated to be brought before the Wyoming Water Development Commission in the fall of 2000, would add 500 acres of irrigation. The depletion associated with this use would amount to 830 acre-feet.

Grieve Reservoir

Grieve Reservoir, which washed out in the summer of 1984, is being considered for rehabilitation and enlargement. This reservoir, if enlarged, is anticipated to serve 300 acres in addition to the original grounds irrigated from the pre-existing structure. The depletion associated with this use would amount to 500 acre-feet.

Muddy Creek

The Muddy Creek Watershed is a candidate for diversions to irrigate up to 1,200 acres of pasture in the lower reaches north of Baggs, WY. At 1.77 feet of consumptive irrigation requirement, this project would result in depletions amounting to 2,100 acre-feet.

Focus Ranch

The Focus Ranch property has a need for supplemental irrigation for 200 acres. The source for this water, likely from storage, is the Roaring Fork near the National Forest boundary. At 0.5 acre-foot per acre supplemental need, this project would result in a depletion of 100 acre-feet.

Pothook – Beaver Ditch

The Little Snake River Conservation District has indicated that a project totaling approximately 400 acres could be brought into production near the confluence of Savery Creek and the Little Snake River. These lands may once have been considered to be served by the Beaver Ditch under an earlier study by the USBR as part of the Savery-Pothook project. At 1.77 feet per acre of consumptive irrigation requirement, this project would result in depletions amounting to 700 acre-feet.

The sum total of projected depletions for the additional agricultural projects listed above is 10,546 acre-feet annually.

Industrial Uses

In the Draft Environmental Impact Statement for Sandstone Reservoir, (Corps of Engineers, Omaha District, January, 1988) the ability to provide 20,000 acre-feet per year for a future industrial developer is presented. At that time a specific need for such water did not exist, although operation studies indicated such water was available for storage and development within the basin.

Industrial use projections outlined by Watts (2000) are used as a starting point to project future industrial use depletions to year 2045 for the Little Snake River Basin. Watts' industrial use projections do not purport to guess in what areas of the basin industrial use will grow, only that the growth will probably come from established industries. While Watts proposes three growth scenarios, only the moderate growth scenario is used herein (as was done with the projections for municipal use as described above). A reasonable approach given the non-spatial nature of industrial demand projections for the Green River Basin is to assign growth in industrial water demand on an area-weighted basis. To do otherwise would effectively discount that industrial growth will likely occur in the Little Snake River Basin. Wyoming's portion of the Little Snake River drainage (approx. 851,975 acres) is about 6.4 percent of the land area of the portion of the Green River Basin located in Wyoming (approx. 13,349,351 acres) (Chris Jessen, personal communication). Applying this basin area percentage (6.4 %) to the moderate industrial growth projection of 40,000 acre-feet per year yields 2,560, rounded to 3,000 acre-feet per year, of industrial water demand in year 2045. Application of the high industrial demand projection would yield an estimate of about 6,400 acre-feet per year. Maintaining the State of Wyoming's ability to provide industrial water when demand arises in the next 45 years is critically important. Based on the above, the future depletion estimate includes 3,000 acre-feet per year.

Summary of Current and Future Depletions

The following current depletion estimates are presented:

Current Use	Depletion, AF/YR
Municipal (In-Basin)	76
City of Cheyenne	14,400
Agricultural	20,050
High Savery Reservoir	7,724
Diked Wetlands	284
Small Reservoirs	49
Total	**42,583**

Future depletions (year 2045) are estimated to be:

Future Use	Depletion, AF/YR
Municipal (In-Basin)	88
City of Cheyenne	22,656
Agricultural	20,050
High Savery Reservoir	7,724
Diked Wetlands	1,284
Small Reservoirs	663
Additional Agricultural Uses	10,546
Industrial Use	3,000
Total	**66,011**

For comparison, these depletions are compared to annual flows seen at one gage on the Little Snake River. The gage, Little Snake River near Dixon, WY (9-2570) provides an indication of the annual flows seen in the river. In addition, two tributaries contributing to flow in the river not included in the gage data are Muddy Creek and Willow Creek. Estimates of flows in these tributaries are also provided. Data are taken from USGS reports, which would already reflect depletions.

Gage or Tributary	Average Annual Flow, AF
Little Snake River near Dixon (1911-1971)	372,600
Muddy Creek (1987-1991)	10,690
Willow Creek (1954-1993)	7,440
Total	**408,860**

Summary

These depletions are independent of the amount of water *available* to Wyoming under provisions of the Upper Colorado River Basin Compact and the Colorado River Compact. The State of Wyoming's apportionment of the waters of the Colorado River System exists in perpetuity. Wyoming therefore continues to retain the right to develop all its available water resources under those Compacts in accordance with current governmental permitting requirements.

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